

WHAT IS CLAIMED IS:

1. An indicator device, comprising:
a substrate; and
an indicator compound disposed on the substrate, the indicator compound being colorimetrically responsive at temperatures below 0°C to volatile bases generated by food decomposition.
2. The device of claim 1, wherein the indicator compound comprises a compound with a color transition in a range from about pH 1.0 and about pH 6.0.
3. The device of claim 2, wherein the indicator compound comprises a compound with a color transition in a range from about pH 2.5 and about pH 5.0.
4. The device of claim 1, wherein the indicator compound comprises a compound with one or more acidic functional groups in the absence of amino or alkylamino functional groups, wherein at least one of the one or more acidic functional groups is -COOH, -SO₃, -S(O₂)O-, or salts thereof.
5. The device of claim 1, wherein the indicator compound is a halogenated xanthene dye, a sulfonated azo dye, or a sulfonated hydroxy-functional triphenylmethane dye.
6. The device of claim 5, wherein the indicator compound is Bromophenol Blue, Phloxine B, Rose Bengal, Congo Red, or Metanil Yellow.
7. The device of claim 1, wherein the device further comprises a first polymeric matrix coated on the substrate

and the indicator compound is disposed within the first polymeric matrix.

8. The device of claim 7, wherein the first polymeric matrix comprises a silicon-containing matrix.

9. The device of claim 1, wherein the first polymeric matrix is formed by an acid catalyzed polymerization of a monomer material.

10. The device of claim 9, wherein the monomer material comprises a tetraalkoxysilane, an alkyl trialkoxysilane, or a mixture thereof.

11. The device of claim 1, wherein the device further comprises a second polymeric matrix covering a portion of the first polymeric matrix, wherein the second polymeric matrix is impermeable to the volatile bases generated by decomposing food.

12. The device of claim 11, wherein the second polymeric matrix covers all of the first polymeric matrix except for a thin strip.

13. The device of claim 1, wherein the device further comprises a polymeric resin disposed within the first polymeric matrix.

14. The device of claim 1, wherein the device further comprises an acidic material disposed within the first polymeric matrix.

15. The device of claim 14, wherein the acidic material is a hydrated alumina, a zeolite, or phosphoric acid.

16. The device of claim 1, wherein the device is adapted for inclusion in a food package.

17. The device of claim 1, wherein the substrate comprises paper, plastic, cotton, flax, resin, glass, fiber glass, or fabric.

18. The device of claim 1, wherein the device consists of materials suitable for use with food.

19. A method of making an indicator device, comprising:
forming a solution of an indicator compound, a solvent, and an acid;
adding a silane monomer material to the solution;
disposing the solution on a substrate; and
polymerizing the silane monomer material on the substrate to form a silica matrix, wherein the indicator compound is disposed within the silica matrix.

20. A method of detecting spoiled frozen food, comprising:
exposing an indicator device to frozen food, the indicator device comprising a substrate and an indicator compound disposed on the substrate, wherein the indicator compound is colorimetrically responsive at temperatures below 0°C to volatile bases generated by spoiled frozen food; and
visually inspecting the device to determine if the food is spoiled by observing if the indicator compound has changed color.

21. The method of claim 20, wherein the indicator device further comprises an amine-impermeable polymeric matrix over the indicator compound and wherein the method further comprises

removing a portion of the amine-impermeable polymeric matrix to expose the indicator compound.

22. The method of claim 21, wherein the method further comprises

determining the amount of decomposition of the food by visually observing the amount of diffusion in a color change of the indicator compound adjacent the portion of the amine-impermeable polymeric matrix which was removed.

23. A food package for use with a food product, comprising:

packaging for a food product; and

an indicator device according to claim 1, associated with the packaging so as to be exposed to volatile bases emitted from the food product.

24. The food package of claim 23, comprising two or more indicator devices according to claim 1, each of the indicator devices having a different amount of indicator compound or having a different amount of acid provided with the indicator compound.

25. The food package of claim 23, wherein the food product is frozen red meat, pork, poultry, processed meat products, or seafood.

26. A method for detecting the presence of an unwanted amine-producing biological agent on a food product, comprising:

exposing an indicator device to the food product, the indicator device comprising a substrate and an indicator compound disposed on the substrate, wherein the indicator compound is colorimetrically responsive to volatile bases emitted by the unwanted amine-producing biological agent; and

visually inspecting the device to determine if the food product contains the unwanted biological agent by observing if the indicator compound has changed color.

27. The method of claim 26, wherein the indicator device further comprises an amine-impermeable polymeric matrix over the indicator compound and wherein the method further comprises

removing a portion of the amine-impermeable polymeric matrix to expose the indicator compound.

28. The method of claim 27, wherein the method further comprises

determining the amount of biological agent on the food product by visually observing the amount of diffusion in a color change of the indicator compound adjacent to the portion of the amine-impermeable polymeric matrix that was removed.

29. The method of claim 26, wherein the food product is grain and the unwanted biological agent is smut.

30. An indicator device, comprising:

a substrate; and

an indicator compound disposed on the substrate, the indicator compound being colorimetrically response, without water mediation, to volatile bases generated by food decomposition.